Relationship of hyperactivity/inattention with adiposity and lifestyle characteristics in preschool children

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Abstract: We performed a cross-sectional study in 450 nonreferred preschool children aged 4 to 6 years to assess the association between hyperactivity/inattention with adiposity and lifestyle characteristics. Measurements included scores of hyperactivity/inattention, adiposity, objectively measured physical activity, television viewing, and eating habits. Higher scores of hyperactivity/inattention were associated with lower percentage body fat, higher levels of physical activity, and less time spent in sedentary activity (all P .01). However, higher scores of hyperactivity/inattention were also associated with more television viewing and less healthy eating habits (all P .04). Except for some selected eating habits (P .07), those relationships remained significant after adjustment for age, sex, and sociodemographic confounders. To conclude, higher scores of hyperactivity/inattention are linked to different lifestyle characteristics that may in part contribute to a future development of overweight/obesity. Precise mechanisms explaining these associations and possible preventive approaches should be further investigated.

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Declaration of conflicting interests

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Abstract

We performed a cross-sectional study in 450 non-referred preschool children aged 4 to 6 years to assess the association between hyperactivity/inattention with adiposity and lifestyle characteristics. Measurements included scores of hyperactivity/inattention, adiposity, objectively measured physical activity, television viewing and eating habits. Higher scores of hyperactivity/inattention were associated with lower percent body fat, higher levels of physical activity and less time spent in sedentary activity (all $P \leq 0.01$). However, higher scores of hyperactivity/inattention were also associated with more television viewing and less healthy eating habits (all $P \leq 0.04$). Except for some selected eating habits ($P \geq 0.07$), those relationships remained significant after adjustment for age, sex and sociodemographic confounders. To conclude, higher scores of hyperactivity/inattention are linked to different lifestyle characteristics that may in part contribute to a future development of overweight/obesity. Precise mechanisms explaining these associations and possible preventive approaches should be further investigated.

Keywords: Hyperactivity/inattention, adiposity, lifestyle.

Introduction

Attention-deficit/hyperactivity disorder (ADHD) is one of the most common mental disorders in children [1, 2] and is characterized by persistent patterns of inattention and/or hyperactivity-impulsivity that cause impairment in at least 2 settings (e.g. school and home) [3]. While ADHD is usually diagnosed in school-aged children, increasing awareness has led to its diagnosis in preschoolers as well, and surprisingly, it was even found that younger children had higher ADHD severity [4]. Nearly 70% of the children in this large study had comorbidities, more commonly oppositional defiant disorder, communication disorders, and anxiety disorders, demonstrating a significant burden already at this young age.

Several studies in school-aged children with ADHD found a higher prevalence of overweight/obesity compared to general population [5, 6] especially when non-medicated [7]. It has been suggested that impulsivity in terms of poor self regulation and increased reward sensitivity may lead to overeating, and to an increased consumption of fatty and sweet foods that have a great rewarding value [8, 9]. This, in turn, could increase the risk for overweight/obesity in children with ADHD [5, 10]. However, only few studies had specifically assessed the scores of hyperactivity/inattention with other eating habits such as soft drinks, fruit and vegetables [10, 11]. Moreover, data regarding preschool children are scarce [12].

Alongside nutritional behavior and eating habits related to impulsivity, other aspects of adiposity-related lifestyle characteristics include physical activity and television (TV) viewing. Although hyperactivity represents one of the major criteria for diagnosis of ADHD, empirical evidence regarding their physical activity is scarce and hardly any studies have investigated their physical activity with objective measures.

There is only one previous study, in 24 boys aged 6 to 12, demonstrating higher levels of physical activity in those with ADHD compared to controls, but the study did not investigate if these children presented with different physical activity patterns or intensities [13]. Further, cross-sectional and longitudinal studies found that higher TV watching at preschool age was associated with higher levels of ADHD-symptoms [14, 15], while studies in older children and adolescents did not show such associations [16, 17].

To our knowledge, no single study has investigated the association between hyperactivity/inattention with adiposity and different lifestyle characteristics in younger children. Therefore, our objective was to assess the relationship between scores of hyperactivity/inattention and adiposity measures such as body mass index (BMI) and body fat, as well as objectively measured physical activity, TV viewing and various eating habits in non-referred preschool children.

Methods

Design and participants

Baseline data from the Ballabeina study (clinicaltrials.gov NCT00674544) were collected in late summer of 2008 and used for this current analysis. The study randomly selected 40 preschool classes from adjacent residential areas, with a high migrant prevalence (i.e. ≥ 40.0%), in two Swiss cantons representing the French and German part of Switzerland. The detailed methodological process had been reported previously [18]. The study was approved by the local respective ethical committees, and the parents or legal representatives of each child provided written informed consent.

Of the initial 727 preschool children, 655 consented (participation rate: 90.1%). Of those, 450 children had complete data for all variables studied and were included in the current analysis. Children with and without complete data differed in the prevalence of migrant parents (69.3% vs 82.3%, respectively, $P = 0.001$) and low educated parents (35.6% vs 47.9%, respectively, $P = 0.01$) as well as in hyperactivity/inattention scores (3.2 ± 2.0 vs. 3.6 ± 2.1, respectively, $P = 0.04$), but not in age, sex and BMI (all $P \geq 0.08$).

Measurements

Sociodemographic data

Using a general questionnaire, parental migrant status was determined by the place of birth and educational level as the highest grade of school completed[18]. According to their place of birth, we grouped migrant parents into the five following regions: Portugal, former Yugoslavia, rest of Europe (Germany, France, Spain, Italy and Turkey), Africa and rest of the world. Parents were defined as "migrants" if at least one of them was born outside of Switzerland [19, 20] and as "low educated" if as at least one of them had no education beyond obligatory school (9 years). Further questions included time spent by children with TV viewing (min/day) and use of any medication.

Scores of hyperactivity/inattention

Scores of hyperactivity/inattention were measured using the hyperactivity/inattention subscale of the French [21] and German [22] parental version of the Strengths and Difficulties Questionnaire (SDQ) [23]. The SDQ is one of the most frequently used assessment tools in child and adolescent (aged 4 to 16 years)

mental health [23]. In accordance with the classification systems of the Diagnostic and Statistical Manual of Mental Disorders -4th edition (DSM-IV) [3] and the International Classification of Diseases-10th revision (ICD-10) [24], the SDQ hyperactivity/inattention subscale constitutes a score for ADHD. It has a high sensitivity prediction for diagnosis of any hyperkinetic disorder (ICD-10) or ADHD (DSM-IV) in 5-10 year old children of 72.4% and 61.1%, respectively [25].

Adiposity

Adiposity measures included BMI and percent body fat. Standing height was determined using a mobile scale and body weight was measured using an electronic scale (Seca, Basel, Switzerland; accuracy 0.05 kg) to calculate BMI. The participants' weight status was then established by the Swiss national percentiles [26], as national percentiles are known to be more sensitive than the international ones [27]. According to the Swiss national percentiles, normal weight was defined as BMI < 90th percentile for age and sex, and overweight/obesity was defined as BMI ≥ 90th and obesity as BMI ≥ 97th percentile for age and sex. Percent body fat was used as measure of body fat, and was measured by a 4-polar single frequency bioelectrical impedance device (RJL Systems, Model 101A; Detroit, MI, USA), based on a formula previously validated in a comparable population: Lean mass = ((0.77 x gender) + (0.46 x age) + (0.32 x weight) + (0.41 x height^2/resistance) - 0.77) with boys = 1 and girls = 0, age in years, weight in kg and height in cm [28].

Physical activity

Physical activity was measured with an activity monitor (GT1M, Actigraph, Florida, USA), set to save data in 15 sec intervals (epochs) [18, 29]. This interval was

shown to be adequate to detect the spontaneous activities of preschool children [29]. Participants were instructed to wear the accelerometers around the hip during 5 consecutive days. Validity was defined as at least 3 days of recording (2 weekdays and 1 day on the weekend) [30], with a minimum of 6 h per day. The validity of wearing the accelerometer for 6 h per day was highly correlated with 10 h-validity in this population (n = 502, r = 0.92, P < 0.001, unpublished observations). Data from monitored days were extrapolated to get a daily average by weighing weekdays and weekends ((5 + 2)/7). Sequences of at least 10 min of consecutive zero values were removed and interpreted as accelerometer not worn [31]. Total physical activity was expressed as counts per minute, divided by mean daily wearing time of 10.8 ± 1.2 h). Time spent in moderate-vigorous, vigorous and sedentary activity was defined as the number of epochs (15 sec intervals) per hour spent in activities of ≥ 420 counts, ≥ 842 counts and ≤ 25 counts, respectively [29, 32].

Eating habits

Eating habits were assessed using a semi-qualitative food frequency questionnaire, validated in an identical population within the same study regions [19]. For the analysis of the questionnaire, all the response options were recoded as daily frequencies, and the answers to the respective items were summed up to correspond to the five recommendations and their components, as developed by The Swiss Society of Nutrition [33]. These five recommendations were based on factors implicated in childhood obesity: 1.”Drink water” (aimed at drinking water and decreasing sweetened drinks), 2.”Eat fruit and vegetables” (aimed at increasing eating fruits and vegetables), 3.”Eat regularly” (aimed at eating meals regularly), 4.”Make clever

choices” (aimed at reducing fatty and sweet foods) and 5.”Turn your screen off when you eat” (aimed at reducing the intake of meals and snacks in front of TV).

Whenever needed, teachers or specific translators provided assistance to complete the questionnaires.

Statistical analysis

Statistical analysis were conducted using SPSS version 16.0 (SPSS Inc, Chicago, Il, USA) and Stata 10.1 (Statacorp, College Station, Tx, USA). Data were summarized as mean ± standard deviation (SD) for normally distributed variables and as median (interquartile range) for skewed variables. Differences between children with and without complete data were calculated using linear or logistic regression analyses with preschool class (cluster) as random factor. Linear regression analyses were performed with adiposity, physical activity, TV viewing and eating habits as the outcome and scores of hyperactivity/inattention as the predictor variables, and with preschool class as random factor. Differences in scores of hyperactivity/inattention between normal weight and overweight/obese children were tested by mixed linear regressions. Analyses were also adjusted for sex, age, sociolinguistic region (French and German part of Switzerland) and parental migrant status and educational level as potential confounders. For children and parents, both sexes were pooled for simplicity. Interaction between levels of hyperactivity/inattention and age and sex was also tested. Statistical significance was set at $P < 0.05$.

Results

Baseline characteristics

Four hundred and fifty children with a complete dataset (5.2 ± 0.6 years; 52.2% girls; 69.3% with migrant parents) were analyzed. The most frequent migrant regions were: Portugal (18.9%), former Yugoslavia (22.1%), rest of Europe (33.0%), Africa (10.9%) and rest of the world (15.1%). Eighty-three children were overweight/obese and 44 obese. The mean score of hyperactivity/inattention was 3.2 ± 2.0. A more detailed description of the sample is shown in *Table 1*.

Hyperactivity/inattention and adiposity and lifestyle characteristics

Higher scores of hyperactivity/inattention were not associated with BMI and these scores did not differ between normal weight, overweight and obese children (p = 0.980, data not shown). However, higher scores of hyperactivity/inattention were associated with lower percent body fat, higher levels of total physical activity, more time spent in moderate-vigorous and vigorous activity, and less time spent in sedentary activity (all $P \leq 0.01$, *Table 2*). The association between scores of hyperactivity/inattention and percent body fat was attenuated after adjustment for levels of total physical activity (β-Coefficient, - 0.25; 95% confidence interval (CI), -0.47 to -0.04; $P = 0.02$). Concerning physical activity, a one increase in the score of hyperactivity/inattention was associated with a mean increase in 9 counts per minute. For example, the mean levels of total physical activity were 698.9 ± 163.2 counts per minute in children presenting the lowest scores (scores 0-2) and were 732.2 ± 193.6 counts per minute in children presenting the highest scores (scores 8-10). Higher scores of hyperactivity/inattention were also associated with more TV viewing and less healthy eating habits, such as lower fruit and vegetables consumption and more frequent snacking in front of TV (all $P \leq 0.04$). After adjustment for age, sex, sociolinguistic region, parental migrant status and educational level, all differences

remained significant, except those for consumption of fruit and vegetables (both $P \geq 0.07$). No interactions were found between scores of hyperactivity/inattention and age or sex.

Discussion

This study examined the association between scores of hyperactivity/inattention and adiposity, objectively measured physical activity, TV viewing and selected eating habits in a population of non-referred preschool-aged children. Our results demonstrate a continuous association between scores of hyperactivity/inattention and several lifestyle characteristics in this relatively unstudied population. They also provide important information that can assist in minimizing adverse lifestyle habits in children with ADHD.

With respect to the hyperactivity/inattention questionnaire scores, the mean scores seen in our study were similar to those reported in other non-referred samples of older children and adolescents [34, 35], but lower than those reported in clinical samples [36, 37]. This is somewhat in contrast to previous observations that ADHD symptoms are more severe in younger children [4], but the use of different assessment tools prohibits a direct comparison.

Higher scores of hyperactivity/inattention were not associated with either BMI or weight status, but with lower percent body fat. These findings are in contrast to several studies in older children with ADHD, that show a higher prevalence of overweight/obesity [5, 6], but in agreement with others [12, 38, 39] . A possible reason for the discrepancies between these former studies, is that specific lifestyle

characteristics that influence body weight and composition were not assessed. Our results are nevertheless in accordance with those of a previous study, on children aged 3 to 5 years, which demonstrated a similar prevalence of overweight in children with ADHD as compared with the general population [12]. Regarding body composition, our findings are also similar to those from a former study in 7 year-old boys, that showed lower levels of skinfold thickness in hyperactive compared to non-hyperactive boys [40]. Another important issue is that the children in our study were non-medicated, and were thus unaffected by the potential adverse effects of common stimulant medications such as weight loss and reduced appetite [41, 42]. Therefore, the lower percent body fat could be partly explained by the higher levels physical activity of children with higher scores of hyperactivity/inattention. Indeed, the identified association between scores of hyperactivity/inattention and percent body fat was attenuated after adjustment for levels of total physical activity. Additional longitudinal studies could help to define the role of physical activity in the relationship between ADHD and body composition. The identified association between scores of hyperactivity/inattention and levels of activity in our study confirms data from a prior research in 24 boys aged 6 to 12 years, where boys with ADHD were objectively more active than controls [13]. Therefore, it appears that hyperactivity does not only involve an increase in fidgeting movements, but it is also associated with increased general, large scale motor activity. Our study population was much larger in size, and included both males and females. Concordant with our findings, resting energy expenditure of 69 boys aged 8 to 14 years was greater in those with ADHD compared to controls [6].

Regarding physical inactivity and sedentary behavior, higher scores of hyperactivity/inattention were also associated with higher TV viewing time. This is in

agreement with a previous cross-sectional research in preschool children, where TV watching was associated with levels of ADHD-symptoms [15], while such an association was not found in older children [16, 17]. A longitudinal study reported that hours of TV viewed per day at ages 1 and 3 years, were associated with higher levels of ADHD-symptoms at age 7 [14]. This may indicate that elevated levels of TV may contribute to attention problems – or a reverse causality, where young children with ADHD-symptoms favor TV viewing. Indeed, watching TV may occupy children with ADHD, and parents may therefore be more prone to allow it for longer periods of time [16]. TV viewing is frequently used as a marker of sedentary behavior. However, in the current study using objective measures of sedentary activity, higher scores of hyperactivity/inattention were associated with less time spent in sedentary activity. Therefore, care should be taken when using TV time as a general surrogate for sedentary behavior in this specific population. This discrepancy between TV watching time and sedentarism measurements can be explained by the frequent observations that young children with ADHD-symptoms might be less calm and continuously fidget during TV watching [13, 43].

The only independent association between scores of hyperactivity/inattention and eating habits was found for snacking in front of TV. Higher total TV viewing time could partially explain this relationship. When snacking in front of TV, mostly palatable food are consumed [44]. These usually fatty and sweet foods can also have a rewarding value [8, 9]. It has been suggested that impulsivity in terms of poor self regulation and increased reward sensitivity may indeed lead to an increased consumption of fatty and sweet foods [8, 9]. However, when specifically investigating the intake of fatty and sweet foods, we did not find a direct association with scores of

hyperactivity/inattention in our young children. The identified association between higher scores of hyperactivity/inattention with lower consumption of fruit and vegetables was mediated by parental education. It is known that parental education contributes to children's food choices [45] and that ADHD is more common in children of parents with low education [46]. It is possible that in preschool children impulsivity does not yet affect food choices as they are mainly under parental control. It could also be that at this age differences in food choices are too small to clearly detect such an influence. This is in part confirmed by a prior study in preschool boys that found no differences in nutrient intake between children with and without ADHD [47] and could also explain the lack of increase in adiposity in this age group.

The present work has some limitations. First, its cross-sectional design limits the assessment of cause-effect relationships. Second, the SDQ inattention/hyperactivity subscale cannot establish a formal diagnosis of ADHD. Nevertheless, it is a brief and validated screening tool to assess levels of hyperactivity/inattention, with a high sensitivity prediction for diagnosis of any hyperkinetic disorder (ICD-10) or ADHD (DSM-IV) in 5-10 year old children [25]. A third limitation is that the subscale was only completed by the parents/legal representatives, who have few opportunities to observe their child within the classroom. Indeed, it has been shown that the SDQ prediction works best when it has been completed by both parents/ legal representatives and teachers [25]. However, most previous studies in young children have only used parental/legal representatives' report to define scores of hyperactivity/inattention.

The main strengths of this study include a comprehensive assessment of adiposity and lifestyle characteristics and their relationship to scores of

hyperactivity/inattention, in a relatively large general population of unselected and non-medicated preschool children from both sexes. It also adds knowledge about different physical activity patterns according to scores of hyperactivity/inattention in young children. Another strength is the adjustment for sociodemographic confounders which have not been controlled for in many previous studies.

In conclusion, this study showed that higher scores of hyperactivity/inattention in preschoolers were not associated with BMI or weight status - but did correlate with lower percent body fat. They were also associated with higher levels of total and more time spent in intense physical activity, less time spent in sedentary activity, higher TV viewing time, lower fruit and vegetables intake and more frequent snacking in front of the TV. Thus, we found that higher scores of hyperactivity/inattention are linked to different lifestyle characteristics that work in opposite directions of weight gain or loss. The future development of overweight/obesity in an individual child could be dependent, at least in part, on whichever factors that prevail. The precise mechanisms of rewarding that may explain the continuous association between scores of hyperactivity/inattention, levels of physical activity, television viewing and eating habits, as well as possible preventive approaches, should be further investigated.

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Table 1 Baseline characteristics of the studied population of 450 preschool children

Age, years	5.2 ± 0.6
Girls, n (%)	235 (52.2)
Migrant parents[1], n (%)	312 (69.3)
Low educated parents[2], n (%)	160 (35.6)
Scores of hyperactivity/inattention[3]	3.2 ± 2.0
Adiposity	
Body mass index, kg/m²	15.7 ± 1.4
Overweight/obese[4], n (%), of which	83 (18.4)
Obese[5] n (%)	44 (9.8)
Percent body fat	21.5 ± 4.7
Physical activity	
Total, counts/min	724.2 ± 167.7
Time spent in moderate-vigorous activity[6], epochs/hour	34.9 ± 9.1
Time spent in vigorous activity[7], epochs/hour	9.4 ± 3.9
Time spent in sedentary activity[8], epochs/hour	124.7 ± 22.3
Television viewing, min/day	55.8 ± 49.4
Eating habits[9], servings/day	
Water	3.0 (3.0-3.0)
Caloric beverages	0.7 (0.3–1.2)
Fruit	1.0 (0.5–1.5)
Vegetables	1.3 (0.8–2.0)
Omission of breakfast	0.0 (0.0–0.0)
Fatty foods	0.6 (0.4–0.9)
Sweet foods	1.1 (0.7–1.6)
Meals in front of television	0.0 (0.0–0.4)
Snacks in front of television	0.0 (0.0–0.4)

Data are expressed as mean ± standard deviation, unless stated otherwise;

[1]At least one parent born outside Switzerland.

[2]At least one parent with no education beyond obligatory school (9 years).

[3]According to the hyperactivity/inattention subscale of the Strengths and Difficulties Questionnaire with problem score ranging from 0 to 10.

[4]BMI ≥ 90th percentile, according to the Swiss national percentiles.

[5]BMI ≥ 97th percentile, according to the Swiss national percentiles.

[6] Number of epochs (15 sec intervals) ≥ 420 counts.

[7] Number of epochs (15 sec intervals) ≥ 842 counts.

[8]Number of epochs (15 sec intervals) ≤ 25 counts.

[9]According to the recommendations of The Swiss Society of Nutrition, expressed as median (interquartile range).